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EFFECT OF DIFFERENT DENSITIES OF *ECHINOCHLOA* COLONUM ON THE GROWTH, DEVELOPMENT AND YIELD OF RICE AND THE WEED UNDER MIXED AND MONOCULTURE

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ABSTRACT

Ahmed M, Karim SMR (2021) Effect of different densities of *Echinochloa* colonum on the growth, development and yield of rice and the weed under mixed and monoculture. *Int. J. Sustain. Crop Prod.* 16(2), 11-19.

A pot experiment was conducted at the net house to investigate the effect of different densities of *Echinochloa coloumn* on rice (cv. BRRI dhan32). Five weed densities such as 2, 3, 4, 5 and 6 weeds/pot were grown in pure stands and in mixture with rice. Monoculture of rice was also maintained. All the plant characters except 1000-grain weight of rice were reduced due to competition from *E. coloumn*. The plant characters were decreased progressively with the increase in density. Grain yield was reduced by 89.9% when 6 weeds/pot were competed with single rice plant. The effect of weed density on the grain yield of rice was represented by a rectangular hyperbola. The effect of weed density produced significant reduction in plant characters of the weed both in pure stands and in mixture with rice. When the intra-weed competition and inter-weed competition combined the degree of reduction in plant characters of weed increased further. In the case of weed, total dry matter/plant and seed yield/plant, both in monoculture and mixed culture showed negative linear regression with weed density. The total dry matter/pot and seed yield /pot increased linearly with the increase in weed density. Production of sub-branches of the weed was also reduced linearly with the increase in weed density both in monoculture and in mixture with rice. *E. colonum* is a notorious weed in rice production causing severe yield reduction even under low population density. Therefore, it should be controlled properly from the rice fields before it did the detrimental effects to rice growth.

Key words: *aman rice, E. coloumn, monoculture, weed densities, yield characteristics, crop-weed competition*

INTRODUCTION

Rice is the principal food crop of Bangladesh and about 90% of the population in Bangladesh depends on rice for their major food (IRRI 1981). In Bangladesh rice ranks first in terms of both area and production (BBS 2000). Bangladesh produces 19.41 million metric tons of rice per annum from 6.03 million hectares of land. It covers about 80% of the total cropped area (AIS 1996). The major production of the rice area is covered by *aman* rice comprising about 57.02% of the rice areas of which 12.72% is covered by Broadcast *aman* rice and 44.3% covered by transplant a man rice (BRRI 1989). But the average yield if rice is quite lower (2.76 t/ha) compared to other leading rice producing countries of the world such as Japan, China, Korea and USA where per hectare yield is 6.22, 6.06 and 6.35 tons, respectively.

One of the important yields constrains of rice competition from weeds. When crop and weed plants grow in proximity they obtain their growth requirements from the same limited pool. In such a situation, the supply of one more growth resources may fall below the requirement of the crop-weed community and a rivalry starts between crop and weed for that particular resource or resources. This rival between the crop and weed for common resource is known as crop-weed competition (Shankar 1971). The rice-weed competition is an important aspect of rice production which needs to be studied properly. Among the weed species, which infest rice, *E. colonum* is very important (Kandasamy and Palaniappan, 1990; Govindra Singh, 1991). In crop-weed competition experiment with upland bunded rice, it was observed that *E. colonum* constituted 90% of the total weed population and the crop produced no yield in the unweeded control (Ali 1985). Ali and Sankaran (1984) stated that *Echinochloa crusgalli* and *Echinochloa colonum* were the predominant grass weeds in low land and upland bunded rice respectively. The weed competed with rice at all stages of growth. The severity of weed competition depends upon the factors such as (a) type of weed species, (b) intensity of weed infestation, (c) duration of weed infestation, (d) competing ability of crop plants and (e) climatic condition.

In general modern rice varieties, which are short and have a high fertilizer requirement are less competitive against weeds than tall droopy–leaved, traditional varieties, as a result, yield losses due to weeds are greater in modern varieties. Tall cultivars allowed lower weed infestation and produced higher grain yield than the dwarf cultivars. In addition to highly significant negative correlation between yield reduction caused by weeds and plant height the taller the rice plants the lower the yield reduction (Moddy 1989). Therefore the effect of different densities of weed on rice growth and yield needs to study for calculating the threshold weed density for their control. Sufficient information is not available about the effect of different densities of *E. colonum* on rice in this country. To control the weed effectively, it is also important to know its growth characters under intra- and inter-specific competition. The present study was conducted to study the effect of *E. colonum* under different densities on the growth, development and yield of rice and also to observe the correlation between weed density and different plant characters of rice and the weed.

MATERIALS AND METHODS

Description of the experimental site

The experiment was conducted in pots (30 cm diameter × 28 cm deep) in the net house of the department of Agronomy, Bangladesh Agricultural University, Mymensingh, during the period for June to October 2001. The

soil was more or less natural, low in organic matter content and low in fertility level. Status of phosphorus and cation exchange capacity (CEC) medium and potassium was low (BARC 1989).

Plant material used

Rice cultivar, cv. BRRI dhan32 was used as planting material in the experiment. It was developed by crossing between BR4 and BR2662 for *Aman* season by Bangladesh Rice Research Institute, Jaydebpur, Gazipur, Bangladesh. Its plants are very strong with the he average height of 115-120 cm, and 8-10 tillers/hill. Its required 130-135 days to mature after planting. Its grain is very fine. The grain yield is 4.5-5.0 ton /ha (BRRI 2000).

Weed species used

The tested weed was *Echinochloa colonum*, which was locally known as Khudey shama. It grows round the year in the field. It is coarse, glabrous, annual plant. Stem is more or less erect or prostrate, 70 cm in length, leaf sheaths are smooth or hairy at nods, often tinged with red, ligule absent. The absence of a ligule, often purple tinged leaf sheaths and usually awn less spikelets are the distinguishing characteristics of the species. *E. colonum* can be distinguished from *E. crusgalli* by the absence of awns on the spikelets.

Experimental treatment and design

Five densities of weeds such as 2, 3, 4, 5 and 6 weeds /plot were grown both in monoculture and in mixture with 3 rice plants/pot (Table 1). The treatments were arranged in a randomized Complete Block Design (RCBD) with three replications.

Table 1. The experiment consists of the following eleven treatments

Culture	Treatments	Density
Monoculture of *E. colonum*	C_0W_2	2 weeds/plot
	C_0W_3	3 weeds/plot
	C_0W_4	4 weeds/plot
	C_0W_5	5 weeds/plot
	C_0W_6	6 weeds/plot
Mixture of *E. colonum*	C_3W_2	(3 rice plants + 2 weeds)/pot
	C_3W_3	(3 rice plants + 3 weeds)/pot
	C_3W_4	(3 rice plants + 4 weeds)/pot
	C_3W_5	(3 rice plants + 5 weeds)/pot
	C_3W_6	(3 rice plants + 6 weeds)/pot
Monoculture of rice		3 rice plants/pot

Here, W= weed, C= rice cultivar and subscripts indicate the number of plants in a pot

Data collection

Growth and yield parameters of rice and weed were collected at 20, 40, 60 DAT and at harvest.

Establishment of weed and rice seeding

The pots were filled loamy soil mixed with well rotten cowdung at the rate of 70 g per 1 kg soil. Weed seedlings were raised from the special seedbed prepared with field soil. The seedlings which developed naturally were uprooted carefully and were transplanted in the pots. The density of weed seedlings were by 2, 3, 4, 5, and 6 plants per pot and every hill contained one seedling with 2 leaves. Weeds of other species were removed from the pots time to time to remove competition. Uniform distribution of weed seedling within pot was maintained by replacing young seedling were necessary. Regular watering was done to provide the pots with adequate water supply to the seedling. Other agronomic practices e.g. drainage of excess water, fertilizer application, killing of insects etc. were done when required.

Collection of rice and weed seedlings

Rice seedlings (cv. BRRI dhan32) were collected from the Agronomy filed Laboratory of Bangladesh Agricultural University (BAU) seedbed, which was raised by the authority. The seeds were sown in the seedbed. Rice seedling of 31 days old were planted as per treatment specification, at the rate of 1 plant per hill and all pots contained 3 hill of rice per pot as shown in the treatment.

Fertilizer application

At the final pot preparation, after removing weeds and stubbles from the pots, the fertilizers were applied. Urea, TSP and Gypsum were applied two times as topdressing. First topdressing was done after two weeks of transplanting urea @ 0.72 g/pot, TSP @ 0.50 g/pot and Gypsum @ 0.45 g/pot followed by watering. Second topdressing of Urea 0.72 g/pot were done at 45 days of transplanting.

Harvesting of rice and weed

The harvested crops from individual pot was threshed, cleaned and dried in the sunshine separately and packed in separate paper bags. Stem and leaves were put in a constant temperature oven for three days at 80^0C to recorded dry weights. The roots were collected after two days of harvest. The pots were put under water for 24 hours to soften the soil and the contents of pots were put on steel net. Roots were collected from the soil using

running tap water. The other impurities were removed before placing in the sun. Since *E. colonum* seeds matured in different was flushes, seeds were collected in different dates. The weed seeds were collected at in full maturity and a total of 5 collections were made at three days intervals. The stem and roots collected in the same procedure of crop and same dates. All the samples were put in oven and dried properly at 80^0C for three days to record dry weights.

Statistical analysis

The collected data were analyzed using the MSTAT statistical programme and the mean differences were adjusted by Duncan's Multiple Range Test (Gomez 1984).

RESULTS AND DISCUSSION

Effect of weed densities on growth and yield parameters of rice

Plant height

Plant height of rice was recorded at 20, 40, and 60 DAT (Table 2). The mean effect of weed competition on the plant height of rice was significant (P>0.01). The tallest plant (72.9 cm) was produced under weed free condition and the shortest plant (67.0 cm) under greatest weed competition i.e. under weed density of 6 weeds/pot. On an average 8.7%, plant height was reduced due to weed competition. The effect of weed density on the rice height was more or less similar at different dates of record. Similar reduction of rice height due to competition from *E. colonum* was also observed by Haque (1999) and Razia (2000). The rice height was reduced progressively with the increase in weed density.

Tillers / plant

Significant (p<0.01) difference in number of tillers/plant was also found due to weed competition (Table 2). More than five tillers/plant were produced under weed free condition but it was reduced to 3.04 when six weeds were competed against 3 rice plants. On an average about 38% tiller production was reduced due to weed competition. This competition excluded the crop plants from absorption of nutrients and water from the soil, which ultimately inhibited the production of meristematic tissue. As a consequence of which tiller production was reduced. The mean effect of weed density on the tiller production was statistically insignificant. Among three sampling dates only the effects was significant at 60 DAT. Razia (2000) observed that 43.8% tiller production was reduced due to competition from *E. colonum*. Azmi and Othman (1987) and Azmi (1988) also found similar reduction of tillers/plant due to competition from weeds including *E. colonum* in Malaysia.

Table 2. Effect of weed density on plant height and tiller number/plant of rice at 20, 40, and 60 DAT under mixture with rice

Density weed/pot	Plant height (cm)			Tiller Number/plant		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
0	55.1 a[z]	89.1 a	95.4 a	4.3	5.0	6.0 a
2	53.7 a	83.3 a	90.7 a	1.8	3.8	4.6 a
3	52.1 ab	80.9 ab	80.6 ab	1.7	3.8	3.9 c
4	51.2 ab	80.6 ab	87.9 ab	1.9	3.6	4.2 b
5	48.5 b	77.8 ab	84.7 bc	1.7	3.7	4.0 c
6	44.7 c	76.2 b	80.1 c	1.4	3.8	3.9 c
Level of sig.	**	**	**	ns	ns	*

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$

** = significant at 1% level of probability; * = significant at 5% level of probability; ns = non-significant; DAT = days after transplanting

Total dry matter (TDM) (g/plant)

The effect of weed competition on the plant height and tiller number per plant was reflected on the total dry matter/plant. The highest TDM/plant (34.5 g) was found in weed free pots and the lowest TDM/plant (9.3 g) was in competition with 6 weeds/pot. On an average, 57.7% TDM/plant was reduced due to weed competition in comparison to no weed treatment (Table 3). Razia (2000) observed that the TDM of BRRI dhan29 was reduced by 42.7% when 200 *E. colonum*/m^2 was competed with 40 rice plants. Perera *et al.* (1992), and Janiya and Moody (1990) observed severe reduction of rice TDM due competition from *E. chinochlo* spp. Haque *et al.* (2000) found 50.5% reduction of rice TDM due to competition from 3 plants of *E. colonum* with 3 rice plants. Therefore, the variation in the degree of per cent reduction of rice TDM might be due to deferent varieties and different densities per unit area.

Root–shoot ratio

Root-shoot ratio of a crop is an indication of root or shoots competition ability of the crop. Higher value of the root-shoot ratio indicates the greater root competitive ability (Karim 1999) of the crop. The crops with higher root weight can absorb their nutrients from greater area of root zone. The root shoot ratio of rice was significantly (p<0.01) affected by weed competition (Table 3). The value of the ratio was numerically greater with higher weed density and vice versa. This indicates that under higher competition the production of shoot was comparatively greater than shoot production. In this study the root-shoot ratio was increased more than

70.0% in comparison to weed free treatment when 6 weeds competed with rice plants. However, the reason for increasing the value of root-shoot ratio due to higher weed density is not known to the author.

Panicles/plant

The highest number of panicles per plant (6.5) was observed under weed free condition. It was reduced progressively with the increase of weed density (Table 3). The lowest number of panicles per plants (2.1) was produced when 6 weeds competed with rice plant in a pot. Therefore about 67.7% panicle reductions were reduced due to weed competition. Similar detrimental effect of density of *E. colonum* on the number of panicles of rice was also reported by Haque *et al.* (2000). Razia (2000) found 53.0% reduction of panicles/plant when *E. colonum* competed with BRRI dhan29 at a density of 200/m. She also observed that the degree of reduction under same weed density varied with different varieties of rice.

Number of grains/panicle

The effect of weed completion on grains/panicle was similar to that was on the number of panicles/plants. The higher number of grains/panicle (108.0) was marked in weed free treatment. On an average the production of grains/panicle was reduced by 55.7% due to weed competition (Table 3). A negative linear effect of weed density was observed on the grains per panicle. Razia (2000) observed 40.0% reduction of rice grains / panicle when competed with *E. crusgalli* and 28.7% with *E. colonum*. Similar reduction of grain production due to competition from weeds including *E. colonum* were noted by Haque (1995) and Islam and Karim (2002).

Grain yield/plant (g)

In the present study, weed competition produced significant reduction of grain yield of rice. On an average 76.9% yield loss occurred due to competition from weeds (Table 3). The effect of weed density was also found significant ($P<0.01$). The highest grain yield (6.02 g/plant) was noted under the lowest density (2 weeds/pot). The grain of rice was reduced progressively with the increase in weed density. Heavy pressure from higher weed density provided the crop with less nutrient, water and light and as a result the crop yield was reduced. Similar yield reduction due to competition from *E. colonum* was noted by BRRI (1977), Ali (1985), Haque *et al.* (2000) and Razia (2000). In a study in India, Ali (1985) observed that when 90.0% of weed vegetation in rice field constituted by *E. colonum* competed with rice for full life cycles no rice grains was produced. Similarly, in Bangladesh Razia (2000), in a field experiment observed 56.1% yield reduction when weeds were grown at the rate of 200/m^2. In the field trial of BRRI (1977) 77.8% yield reduction was noticed due to unrestricted growth of *E. colonum*. The effect of density on grain yield was represented by a curve, rectangular hyperbola that means the grain yield / plant was reduced with the increase of weed density. But the rate of decrease reduced with the increased in weed density. When the weed density increased, intra-weed competition was also increased and as the results the degree of weed competition reduced. Similar weed density grain yield relationship on rice was also observed by Islam and Karim (2002).

1000-seed weight (g)

Although numerically higher weight of 1000 seeds (70.40 g) was noted under weed free condition, it was not significantly affected by weed competition (Table 3). Rao and Moody (1992) recorded no significance difference in weight of 1000-seeds due to weed competition. Razia (2000) also found no significant effect of competition from *E. colonum* on 1000 seed weight. However, few other studies observed significant differences in 1000-seed weight of due to competition from different weeds (Wayan *et al.* 1982; Haque 1995).

Table 3. Effect of weed density on total dry matter (TDM)/plant, root-shoot ration, panicles/plant, grains number/panicle, grains/plant and 1000-seed weight of rice under monoculture and mixture wish rice at harvest

Density of weed/ pot	Total dry matter/plant (g)	Root-shoot ratio	Panicles/ plant	No. of grain/ panicle	Grains/ plant (g)	1000-seed weight (g)
0	34.5 a[z]	5.1 d	6.5 a	108.0 a	12.71 a	17.40
2	20.7 a	6.2 c	4.1 a	85.0 a	6.02 a	17.14
3	16.2 b	6.3 c	3.5 b	57.7 b	3.54 b	17.36
4	14.1 c	7.2 b	3.3 bc	40.0 c	2.18 c	17.37
5	12.7 d	8.9 a	3.0 c	32.3 d	1.73 cd	17.27
6	9.3 c	7.5 b	2.1 c	24.3 c	1.23 d	17.33
Level of sig.	**	**	**	**	**	ns

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$
** = significant at 1% level of probability; ns = non-significant; DAT = days after transplanting

Effect of weed densities on growth and yield parameters of weed

Plant height

Plant height of the weed was recorded at 20, 40, and 60 DAT, both in monoculture and in mixture with rice. Mean effect of weed competition produced 5.65% reduction of weed height in comparison to weed monoculture. The mean effects of weed density on plant height of weed found significant ($P<0.01$) both in monoculture and in mixture. Under both the condition the tallest plants (69.9 cm and 66.0 cm, respectively). The

tallest plants were recorded under the lowest weed density (2 weed/pot) and the shortest plants (59.3 cm, 56.8 cm, respectively) with the highest weed in the density of 6 weeds/ pot (Table 4). The plant height was reduced progressively with the increase of the density. Therefore, gradual reduction of plant height with the increase in weed density might be due to intra-specific competition of *E. colonum*, Hoque (1995) also observed similar negative linear relationship between the weed density and plant height of *E. colonum*.

Table 4. Effect of weed density on plant height (cm) of weed at 20, 40, and 60 DAT under monoculture and mixture with rice

Density of weed/pot	20 DAT		40 DAT		60 DAT		Mean		
	Monoculture	Mixture	Monoculture	Mixture	Monoculture	Mixture	Monoculture	Mixture	Mean
2	51.2 a[z]	49.0 a (11.2)[y]	71.5	69.2 (3.3)	83.0 a	79.7 a (3.9)	69.9 a	66.0 a	67.9 a
3	52.3 b	48.3 a (7.7)	70.6	67.2 (4.9)	80.3 ab	77.2 a (4.0)	67.8 a	64.2 a	66.0 ab
4	50.03 b	45.1 b (9.9)	67.2	63.7 (5.3)	79.7 ab	75.1 ab (5.9)	65.7 a	61.3 ab	63.4 bc
5	45.4 c	40.3 c (11.2)	68.7	62.5 (9.0)	79.7 ab	73.6 ab (3.6)	64.6 ab	60.5 ab	61.7 c
6	40.2 d	37.6 d (6.3)	63.5	60.5 (4.8)	74.2 ab	69.65 b (6.2)	59.3 b	56.8 b	57.6 b
Mean	48.6	43.4	68.3	64.6	79.4	75.1	65.4	61.7	63.4
Level of sig.	**	**	ns	ns	*	*	*	*	**

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$

** = significant at 1% level of probability; * = significant at 5% level of probability; ns = non-significant; DAT = days after transplanting

[y] Figure in parenthesis indicate percent reduction in comparison to monoculture.

Number of tillers/plant

The number of tillers/plant was also recorded at three dates like plant height. Differences in taller production were observed under different weed densities both in monoculture and in mixture. When a comparison between monoculture and mixture was made, it was observed that the tiller production of *E. colonum* was more reduced by 3.30% due to competition with rice. More or less similar results were noted in all the sampling dates, 20, 40 and 60 DAT (Table 5). The density effect of the weed was also found significant ($P<0.01$). The highest number of tillers/plant (11.73) was noted under 2 weeds/pot. Therefore, more than 11% tiller production of *E. colonum* was reduced due to increase of weed density from 2-6 weeds/m^2. More or less similar results were observed under monoculture and mixture with rice. Haque (1995) observed similar gradual reduction of tillers / plant with the increase in weed density in pot experiment. Yamagishi *et al.* (1977) marked that tiller production of *E. crusgalli* (a very similar species of *E. colonum*) was reduced with higher density but with different rate. They found the relationship of tillers/plant and the weed density under pure stands as good fit to logarithmic regression equation.

Table 5. Effect of weed density on tiller number/plant of weed at 20 DAT, 40 DAT and 60 DAT under monoculture and mixture with rice

Density of weed/pot	20 DAT		40 DAT		60 DAT		Mean	
	Monoculture	Mixture	Monoculture	Mixture	Monoculture	Mixture	Monoculture	Mixture
2	5.29 a[z]	5.03 a (4.91)y	13.02 a	11.80 a (9.37)	20.13 a	19.63 a (92.48)	12.81 a	12.15 a
3	5.29 a	4.53 ab (14.37)	12.10 b	11.60 ab (4.13)	19.23 b	18.91 b (1.66)	12.21 ab	11.68 ab
4	5.20 a	4.47 b (14.20)	11.92 bc	11.49 ab (3.61)	18.72 b	8.05 c (3.85)	11.94 bc	11.87 a
5	4.86 b	4.70 ab (3.29)	11.82 bc	11.12 bc (5.29)	17.96 c	17.93 c (0.20)	11.55 bc	11.25 ab
6	4.66 b	4.26 b (8.58)	11.29 c	10.83 c (4.07)	17.80 c	17.46 c (1.35)	11.25 c	10.85 b
Mean	48.62	4.60	12.03	11.37	18.77	18.39	11.95	11.56
Level of sig.	*	*	**	*	**	**	*	*

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$.

** = significant at 1% level of probability; * = significant at 5% level of probability; DAT = days after transplanting

[y] Figure in parenthesis indicate per cent reduction in comparison to monoculture.

Total dry matter (g) /plant

The total dry matter/plant (TDM) of weed was recorded at final harvest only. Since, the TDM is positively related to the plant height and the number of tillers/plant, the effects of weed density on the weed height and tillers/weed were reflected on the effects on weed TDM. A significant effect ($P<0.01$) of crop-weed competition was observed on the weed TDM (Table 6). When a comparison was made between monoculture of weed and mixture with rice, it was observed that about 8.4% extra weed TDM was reduced due to competition from rice. The effect of weed density was also found significant. The highest mean TDM (20.2 g/plant) of the weed was

noted under 2 weeds / pot and the lowest TDM/plant (11.01 g) was found fewer than 6 weeds/pots. Therefore, about 45.5% reduction in accumulation of total dry matter occurred due to increase of weed density from 2-6 weeds/pot. Haque (1995) observed a 32% reduction of weed TDM when weed density was increase from 2-4 weeds/pot. Yamagishi *et al.* (1977) in a correlation study observed that the weed density and TDM/plant of *E. crusgalli* gave a good fit to logarithmic regression equation in monoculture of weed.

Root-shoot ratio

The effect of crop-weed competition on the root-shoot ratio of *E. colonum* was found insignificant. The effect of weed density was also insignificant both in monoculture and in mixture with rice. This indicates that the density effect of weed on the shoot and that on the root was similar (Table 6). However, Haque (1995) in his study obtained a significant negative effect of crop-weed competition on the root-shoot ratio of *E. colonum*. The reason of this discrepancy might be due to difference in seraphic and climatic conditions of two different experiments.

Root weight (g)/plant

The root weight/ plant of the weight was significantly (P<0.01) affected by the effect of weed competition (Table 6). On an average 9.8% of root production of weed was more reduced due to competition from rice. The effect of weed density was similar to that on total dry matter. The highest mean root weight (5.47 g/plant) was found less than 2 weeds/pot and lowest root weight (2.96 g/plant) was found less than 6 weeds/pot. That means, the root weight was progressively reduced with the increase in weed density. The relationship between root weight and weed density was more or less same in monoculture and in mixture. Similar reduction of root weight in *E. colonum* due to higher weed competition was also noted by Haque (1995).

Table 6. Effect of weed density on total dry matter (TDM)/plant, root-shoot ration, and root/weight plant of weed under monoculture and mixture wish rice at harvest

Density of weed/pot	Total dry matter (TDM)/ plant (g)			Root-shoot ratio			Root weight/ plant (g)		
	Monoculture	Mixture	Mean	Monoculture	Mixture	Mean	Monoculture	Mixture	Mean
2	21.27 a[z]	19.13 a (10.06)[y]	20.20 a	1.20	2.18	2.19	5.72 a	5.23 a (8.57)	5.47 a
3	18.24 b	17.29 b (5.21)	17.76 b	1.96	2.13	2.05	5.29b	4.75 b (10.21)	5.02 b
4	16.62 c	15.54 c (6.50)	16.08 c	1.98	2.10	2.04	4.76 c	4.29 c (9.87)	4.52 c
5	12.94 d	11.83 d (8.58)	12.39 d	2.12	2.20	2.16	3.46 b	3.08 b (10.72)	3.27 d
6	11.73 c	10.28 e (12.36)	11.01 e	1.28	2.21	2.24	3.12 e	2.80 c (10.26)	2.96 e
Mean	16.16	14.81	15.84	2.11	2.16	2.14	4.47	4.03	4.25
Level of sig.	**	**	**	*	ns	ns	**	**	**

Figure in parenthesis indicate percent reduction in comparison to monoculture

[z]Means within column followed different letters are significant according to the DMRT test at p < 0.05

** = significant at 1% level of probability; * = significant at 5% level of probability; ns = non-significant

[y] Figure in parenthesis indicate percent reduction in comparison to monoculture

Number of panicles / plant

The number of panicles is an important plant character which is positively related to seed yield. A significant (P<0.01) difference in panicle production was observed in *E. colonum* due to crop competition. On an average, more than 5% less panicles were produced in the weed when it competed with rice. The mean effect of weed density on its panicle production was also significant (P<0.01). The highest number of panicles/plant (11.5) was produced under 2 weeds/pot and the lowest number (9.2) in 6 weeds/pot. The panicle production of the weed was reduced gradually with the increase in weed density. More than 20% panicles were reduced when the weed density was increased from 2-6 weeds/pot (Table 7). However, the rate of reduction was different under different weed densities. The effect of weed was density on panicle production of the weed was more or less similar under monoculture and in mixture. Similar reduction of weed panicles due to competition from rice was also reported by Haque (1995).

Number of sub-branches / branch

The highest number of sub-branch (3.54) was found under the lowest weed density (2 weeds/pot) and the lowest number of sub-branch (2.26) was found under the highest weed density (6 weeds/pot) (Table 7). Therefore, the number of sub-branches reduced gradually with the increase in weed density. From this study it is obvious that competition from *E. colonum* produced significant yield reduction of rice even under lower weed density. Most of the plant character of rice reduced progressively with increase in weed density. The plant characters of weed were also affected by the intra-weed and inter-weed competition. Per plant characters were reduced progressively but the characters per pot e.g. weed seed per pot increased progressively with the increase in weed density. Therefore, proper control measure of *E. colonum* should be done before the critical weed density i.e. the density at which significant yield loss occur, reached. It must be removed at least before seed setting to avoid the crop damage from this weed and to avoid the weed seeds to be deposited in the weed seed bank.

Table 7. Effect of weed density on panicle number/plant and sub-branches for main tiller or weed under monoculture and mixture with rice at harvest

Density	Panicle Number/plant			Tiller Number/plant		
weed/pot	Monoculture	Mixture	Mean	20 DAT	40 DAT	60 DAT
2	11.8 a[z]	11.2 (5.1)[y]	11.5 a	3.59 a	3.59 (0.0)	3.54 a
3	10.5 b	10.0 b (4.9)	10.3 b	3.52 ab	3.54 (-0.1)	3.53 a
4	10.4 b	9.4 c (9.8)	9.9 c	3.34 b	2.93 (12.15)	3.14 b
5	9.8 c	9.5 bc (2.6)	9.6 c	2.37 c	2.23 (5.99)	2.30 c
6	9.3 d	9.0 c (3.2)	9.2 d	2.32 c	2.21 (4.96)	2.26 c
Mean	10.4	9.82	10.1	3.67	2.94	3.00
Level of Sig.	**	*	**	**	ns	*

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$
** = significant at 1% level of probability; * = significant at 5% level of probability; NS = non-significant; DAT = days after transplanting
[y]Figure in parenthesis indicate per cent reduction in comparison to monoculture

Seed weight (g)/ plant

The effects of weed density on the number of panicles/plant and seed/panicle were reflected on the seeds/plant (Table 8). In general, seeds per plant were reduced progressively with the increase in weed density both in monoculture and in mixture. Harper (1977) Stated that the plant behavior varies in monoculture and in mixture due to ecological interaction. It was observed that seed production per pot increased progressively with the increase in weed density both in monoculture and in mixture.

1000 –seed weight (g)

No significant difference was observed in 1000-seed weight of the weed in monoculture and in mixture with rice. The effect of weed density on individual seed weight was also insignificant (Table 8).

Number of seeds/panicle

Since reproduction growth is closely related to vegetative growth of the weeds, the effect of weed density on vegetative characters of the weeds were reflected on its seed production. Seed production per panicle was therefore, significantly affected by the intra-specific and inter-specific competition of the weed (Table 8). On an average 14.5% seeds/panicle was reduced due to competition from rice. The mean effect of weed density was also significant ($P<0.01$) on seed production. Seed production per panicle reduced gradually due to increase in weed density. The highest number of seeds/panicle (40.28) was produced under 2 weeds/pot and the lowest number (26.45) under 6 weeds/pot. Therefore, more than 34% seed production per panicle of the weed was reduced when weed density was increased from 2-6 weeds/pot. The trend of reduction in seed production per panicle was more or less similar both in monoculture and in mixture with rice.

Table 8. Effect of weed density on seed root/weight plant, 1000-seed weight and seeds/panicles of weed under monoculture and mixture wish rice at harvest

Density of	Seed weight/pant (g)			1000-seed weight (g)			Number of seeds/panicle		
weed/pot	Monoculture	Mixture	Mean	Monoculture	Mixture	Mean	Monoculture	Mixture	Mean
2	2.97 a[z]	2.91 a (2.0)[y]	2.94 a	0.78	0.77	0.78	42.78 a	37.77 a (11.7)	40.28 a
3	2.67 ab	2.45 b (4.7)	2.51 b	0.78	0.77 (0.0)	0.78	40.73 ab	34.99 b (14.1)	37.86 b
4	2.35 bc	2.22 c (5.5)	2.29 c	0.77	0.77 (6.0)	0.77	39.35 b	31.46 c (20.1)	35.41 c
5	2.16 bc	1.95 d (9.7)	2.05 d	0.77	0.77 (0.0)	0.77	30.03 c	27.07 d (10.8)	28.55 d
6	1.83 c	1.29 a (29.5)	1.56 e	0.77	0.76 (0.0)	0.77	27.48 d	25.42 e (7.5)	26.45 d
Mean	2.31	2.15	2.2	0.78	0.77	0.77	36.74	31.34	33.71
Level of sig.	*	**	**	ns	ns	ns	**	**	**

[z]Means within column followed different letters are significant according to the DMRT test at $p < 0.05$
** = significant at 1% level of probability; * = significant at 5% level of probability; ns = non-significant
[y]Figure in parenthesis indicate per cent reduction in comparison to monoculture

CONCLUSION

The present study revealed that when the intra-weed competition and inter-weed competition combined the degree of reduction in plant characters of weed increased further. In the case of weed, total dry matter/plant and seed yield/plant, both in monoculture and mixed culture showed negative linear regression with weed density. The total dry matter/pot and seed yield/pot increased linearly with the increase in weed density. Production of sub-branches of the weed was also reduced linearly with the increase in weed density both in monoculture and in mixture with rice. *E. colonum* is a notorious weed in rice production causing severe yield reduction even under low population density. Therefore, it should be controlled properly from the rice fields before it did the detrimental effects to rice growth.

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